

Mechanical Properties of Brick Masonry using Stone Dust as Partially Replacement with Sand in Mortar

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Abstract— This paper presents the experimental investigation of mechanical properties of brick masonry using stone dust as partially replacement with sand in masonry mortar. As part of research the main goal of work is to determine compressive strength, modulus of elasticity and bond strength of brick masonry specimen. The brick masonry specimen made with common building brick available in Ahmedabad region throughout the work and two different mortar proportions 1:3 and 1:6 (cement: sand) adopted. The water to cement ratio (W/C) 0.60 is constant throughout experiment work. Sand was replaced by sand stone dust of 0%, 25%, and 50% by weight of sand in mortar mixes for 7 days of tests and 0%, 20%, 30%, 40% and 50% replacement in mortar mixes used for the 28 days of tests. After completion of curing period, the mechanical properties were measured. From the experiment work, it was concluded that up to 30% replacement of sand stone dust with sand is possible and give reliable results.

Key words: Brick Masonry, Stone Dust, Mechanical Properties, Replacement

I. INTRODUCTION

Masonry is the oldest building material that is still used in the building industry. The brick masonry to be used either as infill walls in reinforced concrete buildings or as primary load bearing constituent of low rise masonry structure Brick masonry is product of brick and mortar. Sand is basic material used in construction of building. Due to its rapid use, the available sources of natural river sand are getting exhausted and rate of sand is also increases day by day. On the other hand, there are lots of stone mines in Saurashtra region which produce stone dust in large quantity while cutting the stone. The sand stone dust creates disposal problem, environmental problem due to its non-fertile properties and causing health hazards.

The study was carried out to check feasibility of replacement of stone dust with river sand in masonry mortar. So, an alternative material of sand is mitigating the increasing demand of sand. In industrial advanced contrary, utilization of stone dust like marble powder, stone slurry etc. has been accepted as replacement of fine aggregate and concluded that the replacement give batter results in properties of mortar. The main objective of the work is to determine the mechanical properties like compressive strength, modulus of elasticity using stress v/s strain graph and shear strength of masonry specimen for ensuring the sand stone dust replacement with sand in masonry mortar is possible or not.

II. MATERIALS

The basic material for mortar is cement, sand and/or sand stone dust, and water.

A. Cement

In this study, ordinary Portland cement of 53 grade satisfying all the required specification of Indian standard IS 1489 part I (1991) was used.

B. Brick

The brick used for making masonry specimen is locally available common building brick in Ahmedabad region. The various tests done on the Brick and their properties are as followed.

Properties	Values
Dimension Of Brick	210 x 100 x 70 (mm ³)
Avg. Dry Weight	2.25 Kg
Avg. Mass Density	1583.2 Kg / m ³
Avg. Weight Density	15.52 KN / m ³
Avg. Water Absorption	16.24 %
Avg. Compressive Strength	5.17 MPa
Brick class	Common Building Bricks
Modulus Of Elasticity	1250 MPa

Table 1: Properties of Bricks

C. Sand & Stone Dust

The sand is used for make the mortar was well graded sand. Sand stone dust collected from Stone dust site in Una, Saurashtra region. The various properties of sand and Sand stone dust are showing below.

CHEMICAL COMPONENT	STONE DUST	RIVER SAND
SiO ₂	1.17%	62.25%
Al ₂ O ₃	1.60%	18.41%
Fe ₂ O ₃	1.88 %	0%
CaO	48.94%	2.11%
K ₂ O	0%	2.41%
MgO	2.07%	2.68%
Chloride	0.009%	0%
FeO	0%	10.84%
LOI	42.13%	0.46%

Table 2: Chemical Properties of Sand & Stone Dust

Sieve size	River sand		Sand Stone dust	
	Cumulative mass retained (g)	Cumulative present (%) retained	Cumulative mass retained (g)	Cumulative present (%) retained
4.75 mm	58.5	5.86	0	0
2.36 mm	122	12.237	5.56	1.12
1.18 mm	278.5	27.934	59.12	11.92
600 μm	412	41.324	128.47	25.90

300 μm	782	78.435	289.22	58.32
150 μm	980.5	98.345	416.46	83.98
Pan	1000	100	498.5	100

Table 3: Sieve Analysis Data

Properties	Value of river sand	Value of SSD
Bulk Density (Loose)	1510.23 kg/m^3	1348.35 kg/m^3
Bulk Density (Dense)	1632.58 kg/m^3	1545.93 kg/m^3
Fineness Modulus	2.64	1.92
Grading zone	II	III
Specific Gravity	2.65	2.71
Water absorption	1.52%	3.12%

Table 4: Properties of Sand & Stone Dust

D. Water

Normal bore well water was used for making mortar.

III. EXPERIMENTAL PROGRAM

The mechanical properties of masonry vary from the properties of basic materials i.e. bricks and mortar. Masonry specimens were casted with different percentage of replacement of stone dust with sand in mortar. Masonry specimens included the 1) masonry prism and 2) shear prism triplet. Masonry mortar proportion is 1:3 and 1:6 (cement: sand) and water to cement ratio (W/C) is 0.60 is adopted for throughout work.

For casting masonry specimen, 0%, 25% and 50% of replacement of stone dust by weight of sand is adopted for 7 day tests and 0%, 20%, 30%, 40% and 50% of replacement of stone dust with sand is adopted for 28 days tests. The mechanical properties are compressive strength, modulus of elasticity and bond strength was measured of masonry specimen and stress v/s strain curve also derive for masonry prism.

A. Brick Masonry Prism

The brick masonry prism casted for the investigation of compressive strength, stress vs strain graph and modulus of elasticity. Brick masonry prism casted according to the specification of IS 1905-1987.

The brick masonry specimen dimension finalized at 210 X 210 X 480. The bricks were arranged such that vertical joints were staggered. Total 6 layers of bricks were placed with 10 mm joint thickness. The prism was setup in UTM and the load was applied evenly on the specimen with load rate of 2 KN/sec. The load was applied till the failure of specimen. After testing, Vertical splitting cracks were seen on all four sides of prism.



Fig. 1: Brick Masonry Prism



Fig. 2: Testing of Brick Masonry Prism

B. Shear Prism

The shear strength is governing factors for evaluating the capacity of masonry elements. The tests setup shown in below fig. (3) and (4). The vertical load is applied gradually using hydraulic jack till the bond break. The shear strength of masonry has been determined experimentally by testing the triplet specimens in UTM.



Fig. 3: Casting of Shear Prism



Fig. 4: Testing of Shear Prism

IV. RESULTS & DISCUSSIONS

A. Compressive Strength

Compressive strength test of brick masonry prisms were performed as per the IS 1905-1987. Compressive strength of prisms were measure at 7 and 28 days after completion of curing. After measuring compressive, the correction factor for different values of h/t ratio is to be applied; which is given in Table 12 of IS1905-1987. For in this case the correction factor for h/t ratio 2.29, value is 0.76 which multiplied with the experimental compressive strength.

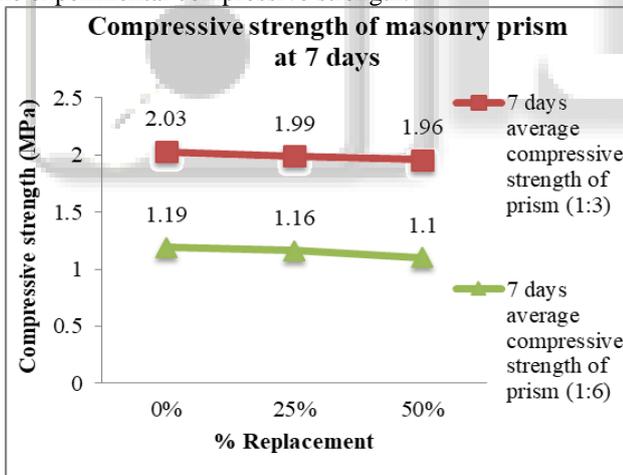


Fig. 5: Compressive Strength of Masonry Prism at 7 Days

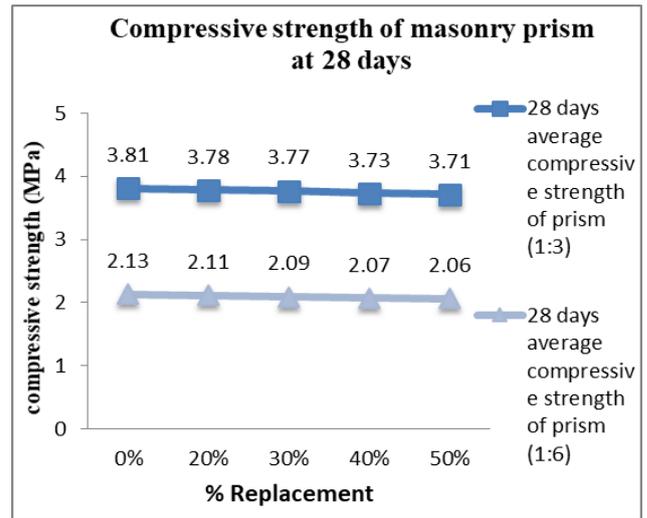


Fig. 6: Compressive Strength of Masonry Prism at 28 Days

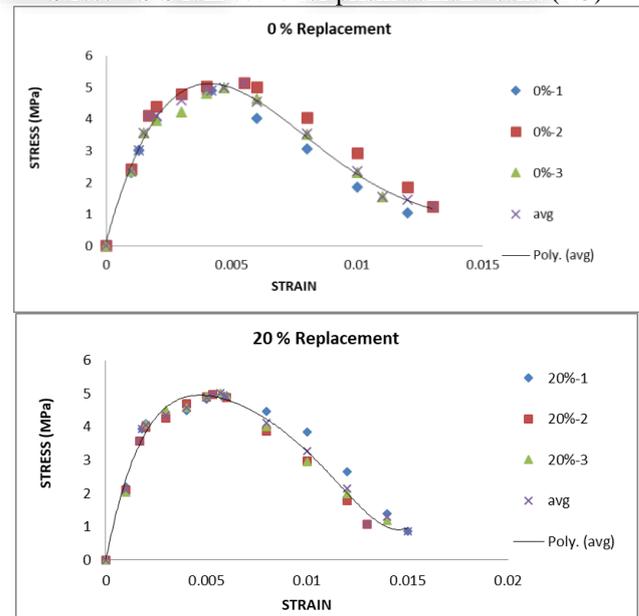
B. Stress V/S Strain Graph for Masonry Prism

Stress Vs strain curve for masonry prism was measured with help of UTM system which connected with the computerized system. The stress vs strain graphs for cement: sand (1:3) and cement: sand (1:6) for every specimen at the age of 28 days were measured. According to this stress vs strain curve, Modulus of elasticity of brick masonry prism was found out.

C. Modulus of Elasticity of Masonry Prism

The Modulus of elasticity of masonry prism has been calculated from the stress - strain curves of prisms. The stress vs strain graphs of compressive stress Vs longitudinal strain for all test specimens which shown above. Taking a tangent on straight portion, it was give the slope value and found out the Modulus of elasticity.

– Stress VS Strain curve for prism cement: sand (1:3)



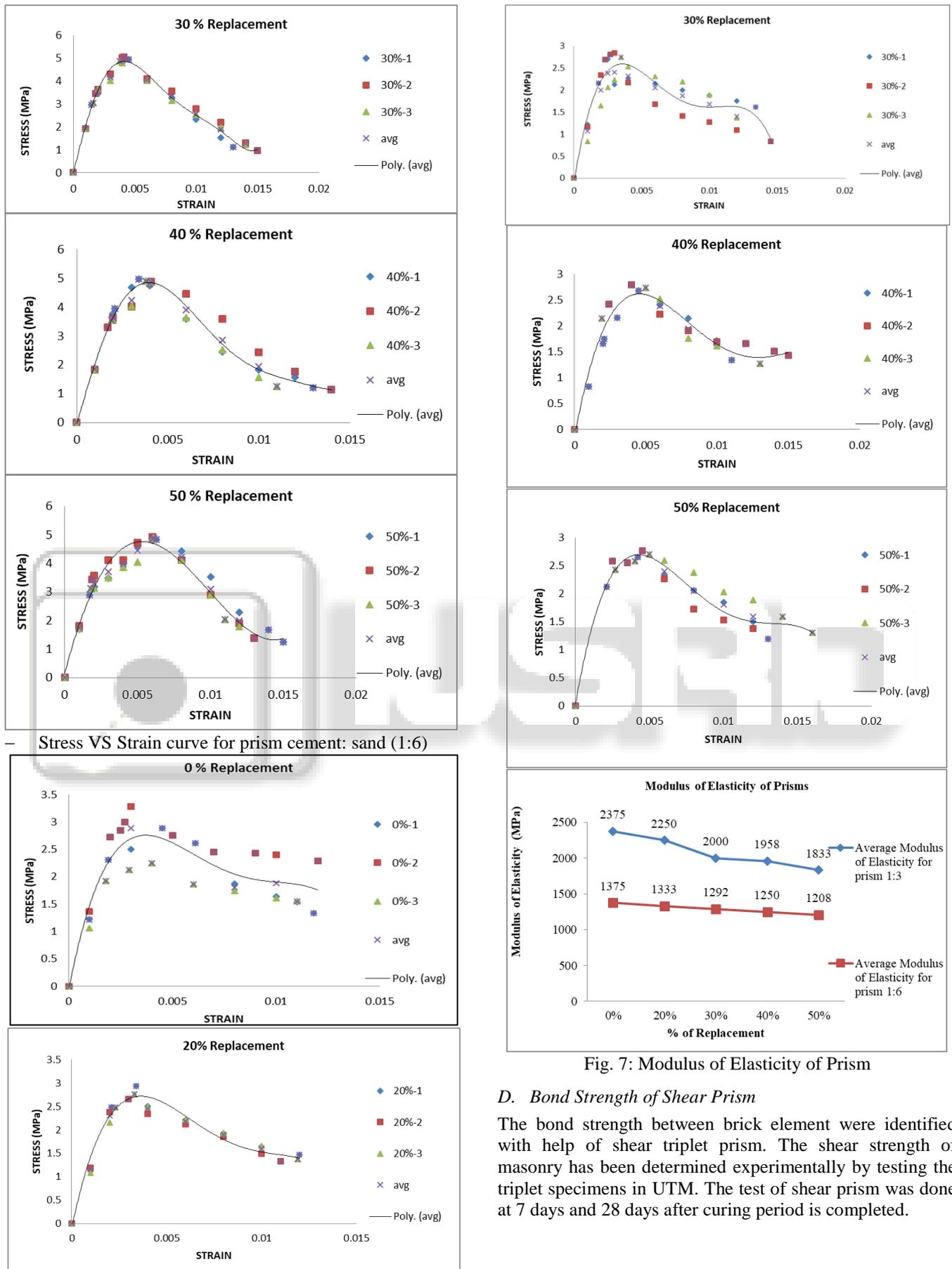


Fig. 7: Modulus of Elasticity of Prism

D. Bond Strength of Shear Prism

The bond strength between brick element were identified with help of shear triplet prism. The shear strength of masonry has been determined experimentally by testing the triplet specimens in UTM. The test of shear prism was done at 7 days and 28 days after curing period is completed.

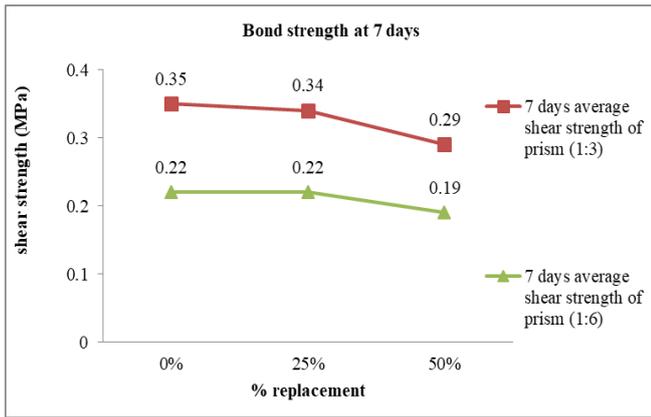


Fig. 8: Bond Strength of Shear Prism at 7 Days

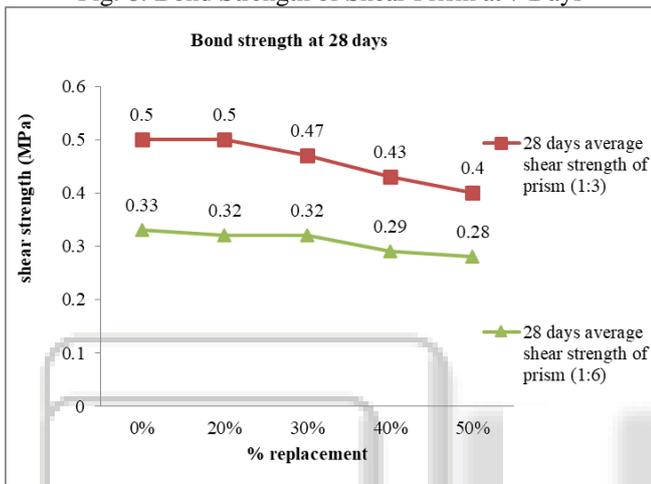


Fig. 9: Bond Strength of Shear Prism at 28 Days

V. CONCLUSIONS

- Failure of masonry prism is due to the formation of vertical splitting along the height of prism.
- After measuring Compressive strength of masonry prism, it was concluded that up to 30% replacement of sand stone dust with sand is give reliable results. For 50% replacement, the value of compressive strength is less but difference is not much more.
- Modulus of elasticity is measured form stress VS strain graph. Failure Stain is measure for 1:3 mortar prisms is up to 0.0020 and for 1:6 mortar prism is 0.0016.
- Bond strength is also same for 0%, 20% and 30% replacement of shear triplet and 50% replacement give lesser value compare to control prism.
- As per results, it was concluded that up to 30% replacement of sand stone dust with sand in masonry mortar is possible in load bearing wall.
- It was also concluded that up to 50% replacement of sand stone dust with sand may be possible in non-load bearing wall.

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